PATENT APPLICATION

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In re the Application of

Makoto KATASE

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For: ELECTROOPTICAL DEVICE UTILIZING ELECTROPHORESIS

SUBMISSION OF VERIFIED TRANSLATION OF FOREIGN PRIORITY DOCUMENT

Director of the U.S. Patent and Trademark Office
Washington, D.C. 20231

Sir:

The benefit of the filing date of prior foreign application JP Application No. 2000-104972 has been requested for the above-identified patent application.

In support of this claim, a verified copy of the English language translation of said foreign application is filed herewith.

It is requested that the Patent and Trademark Office kindly acknowledge receipt of this document.

Respectfully submitted,

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Attachment:
Verified Translation of JP 2000-104972

Date: August 6, 2003

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I am knowledgeable in the English language and in the language in which the below-identified Japanese patent application was filed, and that I believe the English translation of Japanese patent application No. 2000-104972 is a true and complete translation of the above-identified Japanese patent application as filed.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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[Item] Specification 1

[Item] Drawing 1

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[TITLE OF DOCUMENT] SPECIFICATION

[TITLE OF THE INVENTION] ELECTROOPTICAL DEVICE, AND ELECTRONIC DEVICE WITH ELECTROOPTICAL DEVICE INSTALLED

[CLAIMS]

[Claim 1] An electrooptical device comprising an electrooptical layer between electrodes, wherein

the electrooptical layer includes a dispersion medium and particles contained in the dispersion medium,

the particles are colored a first color and the dispersion medium is colored a second color, and

the first color and the second color have a relationship that one is a complementary color of the other.

[Claim 2] The electrooptical device of claim 1, wherein the first color is colored by a color selected from a group including red, green and blue, and the second color is selected from a group including cyan, magenta and yellow.

[Claim 3] An electrooptical device comprising an electrooptical layer between electrodes, wherein

the electrooptical layer includes a dispersion medium and particles contained in the dispersion medium, and

the particles are colored a first color and the dispersion medium is substantially colored black.

[Claim 4] An electrooptical device comprising an electrooptical layer between electrodes, wherein

the electrooptical layer includes a dispersion medium and particles contained in the dispersion medium,

the particles are colored a first color and the dispersion medium is

colored a second color, and

the second color is a color to absorb the first color.

[Claim 5] The electrooptical device of any one of claim 3 or claim 4, wherein the first color is colored by a color selected from a group including red, green and blue.

[Claim 6] An electrooptical device comprising an electrooptical layer between electrodes, wherein

the electrooptical layer has a plurality of cells each including a dispersion medium and particles contained in the dispersion medium, and

the particles are colored differently from each other between said cells.

[Claim 7] The electrooptical device of claim 6, wherein the cells have a cell of which particles are colored red, a cell of which particles are colored green, and a cell of which particles are colored blue.

[Claim 8] The electrooptical device of claim 7 or claim 8, wherein the dispersion medium included in each cell is substantially colored black, is colored so as to absorb a color of the particles included in the dispersion medium of each cell, or is colored so as to be complementary to the particles included in the dispersion medium of each cell.

[Claim 9] An electrooptical device comprising an electrooptical layer between electrodes, wherein

the electrooptical layer has a plurality of cells each including a dispersion medium and particles contained in the dispersion medium, and

the plurality of cells form one pixel.

[Claim 10] The electrooptical device of claim 9, wherein the particles are colored differently from each other between said cells.

[Claim 11] An electronic device in which the electrooptical device of any one of claims 1 to 10 is incorporated as a display.

JP2000-104972

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical Field of the Invention]

The present invention relates to electrooptical devices and electronic apparatuses capable of performing full-color display with superior color reproducibility among display devices utilizing electrophoretic particles.

[0002]

[Prior Art]

Japanese Patent publication No.49-32038 discloses a structure in which dispersion is filled in each pore of a porous spacer having a large number of pores thereby dispersion is divided into minute areas and discontinuous phases. This patent explains that performing color display on the basis of the additive color process by cells which can modulate each divided red, green or blue. (The dispersion has a colored dispersion medium in which electrophoretic particles are dispersed. In actual production, an additive to control electrophoresis, such as a surface-active agent, is frequently included; however, for the sake of a simplified explanation, the explanation will be omitted. It is therefore not meant that the dispersion medium of the present invention will not include the additive such as a surface-active agent. A producer can decide whether or not the additive should be included, in account of a material selected as the colored dispersion medium.

Although an electrophoretic display apparatus capable of altering, so some extent, brightness, chroma and hue has been realized so far, practical materials of dispersion which permits given modulation required to produce color images have not been considered up to now.

[0003]

[Problems to Be Solved by Invention]

In the above-mentioned conventional electrooptical device based on the electrophoresis only can perform blue and white display using both white obtained from titanium oxide and blue obtained from a material of dye. Hence, the object of the present invention is to provide an electrooptical device capable of performing display in multi-colors or the full-colors.

[0004]

[Means for Solving the Problems]

The first electrooptical device of the present invention, to achieve the above-mentioned object, comprises an electrooptical layer between electrodes, wherein the electrooptical layer includes a dispersion medium and particles contained in the dispersion medium; the particles are colored a first color and the dispersion medium is colored a second color; and the first color and the second color have a relationship that one is a complementary color of the other.

[0005]

In one example of the above-mentioned first electrooptical device, the first color is colored with colors selected from a group including red, green and blue; and the second color is selected from a group including cyan, magenta and yellow.

[0006]

In the second electrooptical device of the present invention, the electrooptical layer includes a dispersion medium and particles contained in the dispersion medium; and the particles are colored a first color, and the dispersion medium is substantially colored black.

[0007]

In the third electrooptical device of the present invention, the electrooptical layer includes a dispersion medium and particles contained in

the dispersion medium; the particles are colored a first color, and the dispersion medium is colored a second color; and the second color is a color to absorb the first color.

[0008]

In the above-mentioned second and third electrooptical device, the first color should be colored by a color selected from a group including red, green and blue.

[0009]

The fourth electrooptical device of the present inveinton comprises an electrooptical layer between electrodes, wherein the electrooptical layer has a plurality of cells each including a dispersion medium and particles contained in the dispersion medium; and the particles are colored differently from each other between the cells.

[0010]

In the above-mentioned fourth electrooptical device, the cells preferably should have a cell of which particles are colored red; a cell of which particles are colored green; and a cell of which particles are colored blue. In this case, the dispersion medium included in each cell should be: substantially colored black; colored so as to absorb a color of the particles included in the dispersion medium of each cell; or colored so as to be complementary to the particles included in the dispersion medium of each cell.

[0011]

The fifth electrooptical device of the present invention comprises an electrooptical layer between electrodes, wherein the electrooptical layer has a plurality of cells each including a dispersion medium and particles contained in the dispersion medium, and the plurality of cells form one pixel.

[0012]

In the above-mentioned fifth electrooptical device, the particles should preferably be colored differently from each other between the cells.

[0013]

Also, the electronic device of the present invention comprises any one of the above-mentioned first to fifth electrooptical device as a display.

[Operation]

In the above-mentioned first electrooptical device, the element of each of the three primary colors can be controlled for high intensity of color with the color density, the cell thickness or the size of the microcapsules kept to their minimums.

[0014]

The relationship of dispersion is listed if Tables 1 to 3.

Displayed color	R (red)	G (green)	B (blue)
Colors of electro-phoretic particles	R (red)	G (green)	B (blue)
Colors of dispersion mediums	C (cyan)	M (magenta)	Y (yellow)

Table 1

[0015]

Displayed color	R (red)	G (green)	B (blue)
Colors of electro-phoretic particles	R (red)	G (green)	B (blue)
Colors of dispersion mediums	K (black)	K (black)	K (black)

Table 2

[0016]

Displayed color	R (red)	G (green)	B (blue)
Colors of electro-			

phoretic particles	R (red)	G (green)	B (blue)
Colors of dispersion mediums	Kr (red absorbed)	Kg (green absorbed)	Kb (blue absorbed)

Table 3

[0017]

The color of particles (electrophoretic particles) may be either the color of their core material or the color of their coating materiel. The present invention does not intend limiting the detailed structures and specifications of the coloring.

By way of example, iron oxide may be selected as red (R) particles, cobalt green as green (G) particles, and cobalt blue as blue (B) particles. Many other materials are also available, which are disclosed by Japanese Patent publication No.50-15115, so details about them are omitted here.

[0018]

The color of the dispersion medium may be realized by the color of its material itself or the color of dye. Alternatively, pigment that does not affect electrophoretic particles may be used as the dispersion medium. The present invention does not intend limiting the detailed structures and specifications of the coloring. By way of example, selectable is pigment having an azo group (-N=N-) or an anthraquinone structure and having a color of cyan, magenta, yellow or black.

[0019]

The second and third electrooptical devices can control the element of each of the three primary colors for high intensity of color, and full-color display and multi-color display can be performed with excellent color reproduction.

[0020]

[Embodiments of the Invention]

Referring to the accompanying drawings, the present invention will now be described.

Figs.1 and 2 are sectional views of a cell (CELL) for performing electrophoretic display. For the sake of simplified explanation, the illustration of detailed constituents, such as electrodes and a bulkhead, are omitted. In the figures, a reference P shows electrophoretic particles, a reference L shows a colored dispersion medium, and a reference S shows dispersion containing both electrophoretic particles and dispersion medium. It is frequent that an actual cell additionally uses an additive such as a surface-active agent, but this is omitted in the embodiment. As to the additive, addition or non-addition thereof is arbitrary and any type is selectable. First a fundamental operation will be explained. When applied voltage to the cell causes the electrophoretic particles P to migrate to a user-viewing-side electrode, the state shown in Fig.1 is realized. In this case, a viewer is able to directly see the electrophoretic particles P, so that the viewer can recognize the external color of the particles P. On the other hand, when the electrophoretic particles P migrate to an opposite electrode to the user, the state shown in Fig.2 is realized, where a viewer can recognize a certain color that has experienced the absorption of a color component through the colored dispersion medium L. Although the cell is depicted to have a rectangular section, its shape is not limited to a rectangle, but any shape of the section can be applied to the present invention. Microcapsules described in the claims are also applied to the present invention. An intention of the present invention is combinations of colors of dispersion, which will be explained in detail.

[0021]

Through incidence light used actually contains various wavelength

components, a very simple model is representatively explained for the sake of description of the present invention. However, the present invention is not confined to only such a theoretical model, and it is also applied to the cell used in usual environments (outdoors during the daytime, lighted indoor environments, or others).

[0022]

Incidence light consists of the three primary colors. Concerning the wavelength, the blue (B) is approximately 380 nm, the red (R) is approximately 780 nm, and the green (G) is approximately 520 nm, respectively. The incidence light can I can be decomposed into intensities (IR, IG, IB) of the wavelengths of the three primary colors, of which decomposition is expressed by the following formula.

[0023]

[Formula 1]

$$I=IR + IG + IB \qquad \ldots (1)$$

Reflection brightness (Irefon) for being bright (ON) is determined by the reflectance (Rr, Rg, Rb) of each color component, and expressed by the following formula.

[0024]

[Formula 2]

$$Irefon=(Ir+Ig+Ib) \cdot (Rr+Rg+Rb) \qquad \ldots (2)$$

In contrast, reflection brightness (Irefoff) for being dark (OFF) is determined by the reflectance of each component and the transmittance (Tr, Tg, Tb) of each dispersion medium to each color, which will be expressed by the following formula.

[0025]

[Formula 3]

$$Irefoff=(Ir+Ig+Ib) \cdot (Rr+Rg+Rb) \cdot (Tr^2+Tg^2+Tb^2) \qquad \ldots (3)$$

The inventor of the present invention has devised how to control each component of the R, G and B colors independently with the foregoing formulas (1), (2) and (3) kept true.

That is, the reflection brightness for being bright (ON) is understood as follows if each color is controlled independently. In the case of a cell displaying R (red), it is understood that, from the formula (2) II formula, only the reflectance Rr that reflects the component R is effective and the reflectance (Rg, Rb) of the remaining components is required to be zero or close to zero. Similarly, in the case of a cell displaying G (green), it is understood that, from the formula (2), only the reflectance Rg that reflects the component G is effective and the reflectance (Rr, Rb) of the remaining components is required to be zero or close to zero. Similarly, in the case of a cell displaying B (blue), it is understood that, from the formula (2), only the reflectance Rb that reflects the component B is effective and the reflectance (Rr, Rg) of the remaining components is required to be zero or close to zero. Elements in charge of the reflection are electrophoretic particles, and this results in the necessity that the electrophoretic particles reflect the colors R, G and B.

On the other hand, the reflection brightness for being dark (OFF) is based on the fact that incidence light is absorbed during passing a dispersion medium at a rate dependent on a colored density and a thickness of the medium. Where a cell displays R (red), it is understood that, from the formula (3), only the transmittance Tr that transmits the component R is effective but the transmittance (Tg, Tb) of the remaining components is not effective. Similarly, where a cell displays G (green), it is understood that, from the formula (3), only the transmittance Tg that transmits the component G is effective but the transmittance (Tr, Tb) of the remaining components is not effective. Similarly, where a cell displays B (blue), it is understood that,

from the formula (3), only the transmittance Tb that transmits the component B is effective but the transmittance (Tr, Tg) of the remaining components is not effective. An Element to determine the transmittance is a colored dispersion medium, so that it is understood for the colored dispersion mediums that the transmittance of the colors corresponding to the electrophoretic particles of at least red (R), green (G) and blue (B) are fundamental elements to control modulation. In other words, main members for modulation are colored dispersion mediums of cyan (C), magenta (M) and yellow (Y) that are complementary colors to red (R), green (G) and blue (B), a black (K) dispersion medium capable of absorbing all the components, or colored dispersion mediums to which Kr, Kg and Kb are colored, the Kr, Kg and Kb being capable of absorbing at minimum R, G and B reflected by the electrophoretic particles.

[0026]

[First embodiment]

Figs.3 and 4 show sectional views of a cell for display of red (R). Constituents such as electrodes and a bulkhead are omitted from being depicted for the sake of simplified explanation. Electrophoretic particles Pr have a characteristic of reflecting the component of red (R). A dispersion medium (Lc) is colored cyan (C) to absorb the wavelength component of the red (R). When applied voltage causes the electrophoretic particles Pr to migrate to an electrode located to the user side, a state shown in Fig.3 is realized. In this case, the electrophoretic particles Pr can be seen directly by the user, where the red is displayed brightly. On the other hand, when the electrophoretic particles migrate to the electrode opposite to the user, a state shown in Fig.4 is provided. In this situation, incidence light is subject to absorption of the colored dispersion medium (Lc), reflected by the electrophoretic particles Pr, then again subject to absorption of the colored

dispersion medium (Lc), thereby a dark red or black being displayed. Although the cell is depicted to have a rectangular section, its shape is not limited to a rectangle, but any shape of the section can be applied to the present invention. An intention of the present invention is combinations of colors of dispersion.

Figs.5 and 6 show sectional views of a cell for display of green (G). For the sake of simplified explanation, constituents such as electrodes and a bulkhead are omitted from being depicted in detail. Electrophoretic particles Pg have a characteristic of reflecting the component of green (G). A dispersion medium (Lm) is colored magenta (M) to absorb the wavelength component of the green (G). When applied voltage causes the electrophoretic particles Pg to migrate to an electrode located at the user side, a state shown in Fig.5 is realized. In this case, the electrophoretic particles Pg can be seen directly by the user, where the green is displayed brightly. On the other hand, when the electrophoretic particles migrate to the electrode opposite to the user, a state shown in Fig.6 is provided. In this case, the cell is displayed in a dark green or black, because the incidence light experiences the absorption of the colored dispersion medium (Lm).

Figs.7 and 8 show sectional views of a cell for display of blue (B). For the sake of simplified explanation, constituents such as electrodes and a bulkhead are omitted from being depicted in detail. Electrophoretic particles Pb have a characteristic of reflecting the component of blue (B). A dispersion medium (Ly) is colored yellow (Y) to absorb the wavelength component of the blue (B). When applied voltage causes the electrophoretic particles Pb to migrate to an electrode located at the user side, a state shown in Fig.7 is realized. In this case, the electrophoretic particles Pb can be seen directly by the user, where the blue is displayed brightly. On the other hand, when the electrophoretic particles migrate to the

electrode opposite to the user, a state shown in Fig.8 is provided. In this case, the cell is displayed in a dark blue or black, because the incidence light experiences the absorption of the colored dispersion medium (Ly).

Therefore, using both the three primary colors (RGB) of electrophoretic particles and their complementary colors (CMY) of dispersion mediums enables the cells to have high intensity of color and high contrast, with both of the color density and the cell thickness kept to their minimums. Further, since the cell can be formed into a thinner one, the intensity of an electric field required for electrophoresis can be realized by lower applied voltage than the conventional voltage. Hence the voltage to drive the cell can be lowered markedly. Further, the thinner cell makes it possible to switch the cell ON/OFF at higher speed, which leads to display of dynamic images identical or superior to or than that performed with liquid crystal display.

[0027]

[Second embodiment]

Figs.9 and 10 show sectional views of a cell for display of red (R). For the sake of simplified explanation, constituents such as electrodes and a bulkhead are omitted from being depicted. Electrophoretic particles Pr have a characteristic of reflecting the component of red (R). A dispersion medium (Lk) is colored black. When applied voltage causes the electrophoretic particles Pr to migrate to an electrode located at the user side, a state shown in Fig.9 is realized. In this case, the electrophoretic particles Pr can be seen directly by the user, where a bright red is displayed. On the other hand, when the electrophoretic particles migrate to the electrode opposite to the user, a state shown in Fig.10 is provided. In this case, the cell is displayed in a dark red or black, because the incidence light experiences the absorption of the colored dispersion medium (Lk).

Although the cell is depicted to have a rectangular section, its shape is not limited to a rectangle, but any shape of the section can be applied to the present invention. An intention of the present invention is combinations of colors of dispersion.

Figs.11 and 12 show sectional views of a cell for display of green (G). For the sake of simplified explanation, constituents such as electrodes and a bulkhead are omitted from being depicted. When applied voltage causes electrophoretic particles Pg to migrate to an electrode located at the user side, a state shown in Fig.11 is realized. In this case, the electrophoretic particles Pg can be seen directly by the user, where a bright green is displayed. On the other hand, when the electrophoretic particles migrate to the electrode opposite to the user, a state shown in Fig.12 is provided. In this case, the cell is displayed in a dark green or black, because the incidence light experiences the absorption of the colored dispersion medium (Lk).

Figs.13 and 14 show sectional views of a cell for display of blue (B). For the sake of simplified explanation, constituents such as electrodes and a bulkhead are omitted from being depicted. When applied voltage causes electrophoretic particles Pb to migrate to an electrode located at the user side, a state shown in Fig.13 is realized. In this case, the electrophoretic particles Pb can be seen directly by the user, where a bright blue is displayed. On the other hand, when the electrophoretic particles migrate to the electrode opposite to the user, a state shown in Fig.14 is provided. In this case, the cell is displayed in a dark blue or black, because the incidence light experiences the absorption of the colored dispersion medium (Lk).

Therefore, using both the three primary colors (RGB) of electrophoretic particles and a black-colored dispersion medium enables the cells to have high intensity of color and high contrast, with both of the color

density and the cell thickness kept to their minimums. Further, since the cell can be formed into a thinner one, the intensity of an electric field required for electrophoresis can be realized by lower applied voltage than the conventional voltage. Hence the voltage to drive the cell can be lowered markedly. Further, the thinner cell makes it possible to switch the cell ON/OFF at higher speed, which leads to display of dynamic images identical or superior to or than that performed with liquid crystal display.

[0028]

[Third embodiment]

Figs.15 and 16 show sectional views of a cell for display of red (R). For the sake of simplified explanation, constituents such as electrodes and a bulkhead are omitted from being depicted. Electrophoretic particles Pr have a characteristic of reflecting the component of red (R). A dispersion medium (Lkr) is colored so as to absorb at least a wavelength component of the red (R). When applied voltage causes the electrophoretic particles Pr to migrate to an electrode located at the user side, a state shown in Fig.15 is realized. In this case, the electrophoretic particles Pr can be seen directly by the user, where a bright red is displayed. On the other hand, when the electrophoretic particles migrate to the electrode opposite to the user, a state shown in Fig.16 is provided. In this case, the cell is displayed in a dark red or black, because the incidence light experiences the absorption of the colored dispersion medium (Lkr). Although the cell is depicted to have a rectangular section, its shape is not limited to a rectangle, but any shape of the section can be applied to the present invention. An intention of the present invention is combinations of colors of dispersion.

Figs.17 and 18 show sectional views of a cell for display of green (G). For the sake of simplified explanation, constituents such as electrodes and a bulkhead are omitted from being depicted. Electrophoretic particles

Pg have a characteristic of reflecting a wavelength component of green (G). A colored dispersion medium (Lkg) is colored so as to absorb at least the component of the green (G). When applied voltage causes the electrophoretic particles Pg to migrate to an electrode located at the user side, a state shown in Fig.17 is realized. In this case, the electrophoretic particles Pg can be seen directly by the user, where a bright green is displayed. On the other hand, when the electrophoretic particles migrate to the electrode opposite to the user, a state shown in Fig.18 is provided. In this case, the cell is displayed in a dark green or black, because the incidence light experiences the absorption of the colored dispersion medium (Lkg).

Figs.19 and 20 show sectional views of a cell for display of blue (B). For the sake of simplified explanation, constituents such as electrodes and a bulkhead are omitted from being depicted. Electrophoretic particles Pb have a characteristic of reflecting a wavelength component of blue (B). A dispersion medium (Lkb) is colored so as to absorb at least the component of the blue (B). When applied voltage causes the electrophoretic particles Pb to migrate to an electrode located at the user side, a state shown in Fig.19 is realized. In this case, the electrophoretic particles Pb can be seen directly by the user, where a bright blue is displayed. On the other hand, when the electrophoretic particles migrate to the electrode opposite to the user, a state shown in Fig.20 is provided. In this case, the cell is displayed in a dark blue or black, because the incidence light experiences the absorption of the colored dispersion medium (Lkb).

Therefore, using both the electrophoretic particles of the three primary colors (RGB) and a colored dispersion medium colored to absorb at least designated one of the three primary colors enables the cells to have high intensity of color and high contrast, with both of the color density and the cell thickness kept to their minimums. Further, since the cell can be

formed into a thinner one, the intensity of an electric field required for electrophoresis can be realized by lower applied voltage than the conventional voltage. Hence the voltage to drive the cell can be lowered markedly. Further, the thinner cell makes it possible to switch the cell ON/OFF at higher speed, which leads to display of dynamic images identical or superior to or than that performed with liquid crystal display.

[0029]

[Fourth embodiment]

Figs.21 and 22 show sectional views of a microcapsule (CAPS) for display of red (R). For the sake of simplified explanation, constituents such as electrodes and a bulkhead are omitted from being depicted.
When applied voltage causes the electrophoretic particles Pr to migrate to an electrode located at the user side, a state shown in Fig.21 is realized. In this case, the electrophoretic particles Pr can be seen directly by the user, where a bright red is displayed. On the other hand, when the electrophoretic particles migrate to the electrode opposite to the user, a state shown in Fig.22 is provided. In this case, the cell is displayed in a dark red or black, because the incidence light experiences the absorption of the colored dispersion medium (Lk). Although the microcapsule is depicted to have a circular section, its shape is not limited to a circle, but any shape of the section can be applied to the present invention. An intention of the present invention is combinations of colors of dispersion.

For displaying the green (G) or blue (B), the constituents of the microcapsule may be selected in a similar manner to the foregoing first to third embodiments.

Therefore, using both electrophoretic particles of the three primary colors (RGB) and a dispersion medium colored black, a complementary colored dispersion medium, or a colored dispersion medium colored to

absorb at least designated one of the three primary colors enables the cells to have high intensity of color and high contrast, with both of the color density and the microcapsule size kept to their minimums. Further, since the microcapsule can be formed into a compact one, the intensity of an electric field required for electrophoresis can be realized by lower applied voltage than the conventional voltage. Hence the voltage to drive the microcapsule can be lowered markedly. Further, the compact microcapsule makes it possible to switch the microcapsule ON/OFF at higher speed, which leads to display of dynamic images identical or superior to or than that performed with liquid crystal display.

[0030]

[Fifth embodiment]

Fig.23 is a plan view showing a plurality of juxtaposed RGB cells. The three types of dispersion Sr, Sg and Sb described by the foregoing first to third embodiments are juxtaposed to compose one pixel. An actual cell needs constituents, such as driving elements and driving electrodes, to send signals of pixel information, but those constituents are omitted from being drawn, so that the illustration is simplified. This embodiment adopts the RGB cells arranged side by side, but those cells may be arranged in a delta shape or others. In the present invention, how to arrange the cells is not restricted, so that the three primary colors may be arranged in any form. In Fig.23, dashed lines exhibit pixels, which are continuously arranged. Each of the cells CELL (R), CELL (G) and CELL (B) is composed by the dispersion described in the foregoing first, second or third embodiment. Hence, arbitrary switching control of the RGB cells enables display in the full-colors.

Therefore, juxtaposing the cells each of which uses both electrophoretic particles of the three primary colors (RGB) and a dispersion

medium colored black, a complementary colored dispersion medium, or a colored dispersion medium colored to absorb at least designated one of the three primary colors enables the cells to have high intensity of color and high contrast, with both of the color density and the cell thickness kept to their minimums. Further, the voltage to drive the cell can be lowered markedly. Further, the thinner cell makes it possible to switch the cell ON/OFF at higher speed, which leads to display of dynamic images identical or superior to or than that performed with liquid crystal display.

If using multi-colors, any two colors are selectable and combined with each other.

[0031]

[Sixth embodiment]

Fig.24 is a plan view showing a plurality of juxtaposed RGB cells. The three types of dispersion Sr, Sg and Sb described by the first, the second and the third embodiments are individually filled into a microcapsule CAPS and a plurality of microcapsules of the same color are formed into each cell CELL (R), CELL (G) or CELL (B). The three cells are juxtaposed to form one pixel. Actual cells need constituents, such as driving elements and driving electrodes, to send signals of pixel information, but those constituents are omitted from being drawn, so that the illustration is simplified. For the sake of a further simplified illustration, structural members including binder to secure the capsule are also omitted from being depicted. This embodiment adopts the RGB cells arranged side by side, but those cells may be arranged in a delta shape or others. In the present invention, how to arrange the cells is not restricted, so that the three primary colors may be arranged in any form. In Fig.24, dashed lines exhibit pixels, which are continuously arranged. The microcapsule CAPS included by each of the cells CELL (R), CELL (G) and CELL (B) is composed by the

dispersion described in the first, second or third embodiment. Hence, arbitrary switching control of the RGB cells enables display in the full-colors. Therefore, juxtaposing the microcapsules each of which uses both electrophoretic particles of the three primary colors (RGB) and a dispersion medium colored black, a complementary colored dispersion medium, or a colored dispersion medium colored to absorb at least designated one of the three primary colors enables the cells to have high intensity of color and high contrast, with both of the color density and the cell thickness kept to their minimums. Further, the voltage to drive the cell can be lowered markedly. Further, the thinner cell makes it possible to switch the cell ON/OFF at higher speed, which leads to display of dynamic images identical or superior to or than that performed with liquid crystal display. If using multi-colors, any two colors are selectable and combined with each other.

[0032]

[Effects of the Invention]

According to the first electrooptical device of the present invention, using colors of electrophoretic particles and their complementary colors (CMY) of dispersion mediums enables the cells to have high intensity of color and high contrast, with both of the color density and the cell thickness kept to their minimums. Further, since the cell can be formed into a thinner one, the intensity of an electric field required for electrophoresis can be realized by lower applied voltage than the conventional voltage. Hence the voltage to drive the cell can be lowered markedly. Further, the thinner cell makes it possible to switch the cell ON/OFF at higher speed, which leads to display of dynamic images identical or superior to or than that performed with liquid crystal display.

[0033]

According to the second electrooptical device of the present invention, using a black-colored dispersion medium enables the cells to have high intensity of color and high contrast, with both of the color density and the cell thickness kept to their minimums. Further, since the cell can be formed into a thinner one, the intensity of an electric field required for electrophoresis can be realized by lower applied voltage than the conventional voltage. Hence the voltage to drive the cell can be lowered markedly. Further, the thinner cell makes it possible to switch the cell ON/OFF at higher speed, which leads to display of dynamic images identical or superior to or than that performed with liquid crystal display. Cost saving can be achieved by coloring dispersion in the common color regardless the color of particles.

According to the third electrooptical device of the present invention, using a colored dispersion medium to absorb colors of eletrophoretic particles enables the cells to have high intensity of color and high contrast, with both of the color density and the cell thickness kept to their minimums. Further, since the cell can be formed into a thinner one, the intensity of an electric field required for electrophoresis can be realized by lower applied voltage than the conventional voltage. Hence the voltage to drive the cell can be lowered markedly. Further, the thinner cell makes it possible to switch the cell ON/OFF at higher speed, which leads to display of dynamic images identical or superior to or than that performed with liquid crystal display. Since coloring of dispersion is restricted less, option of color increases, and property of display can be improved.

According to the fourth electrooptical device of the present invention, both the color density and the cell thickness kept to their minimums enable the cells to have high intensity of color and high contrast. Also, the voltage to drive the microcapsule can be lowered markedly.

Further, thin cells make it possible to switch the cell ON/OFF at higher speed, which leads to display of full-color dynamic images identical to or superior than that performed with liquid crystal display. Multi-color display by combining any two colors also becomes possible. The electrooptical device can be provided for any purpose as the next-generation display which surpasses CRT and liquid crystal displays.

According to the fifth electrooptical device of the present invention, both the color density and the cell thickness kept to their minimums enable the cells to have high intensity of color and high contrast. Further, the voltage to drive the cell can be lowered markedly. Further, the thinner cell makes it possible to switch the cell ON/OFF at higher speed, which leads to display of full-color dynamic images identical to or superior than that performed with liquid crystal display. Multi-color display by combining any two colors also becomes possible. Coating microcapsules onto a flexible substrate is able to provide displays such as sheets of paper that exceed CRTs and liquid crystal displays.

[0034]

In the electronic device of the present invention, the employment of any one of the first to fifth electrooptical devices as a display realizes thin type of displays of which display performance is close to printed matters, which has been one ideal of electronic displays.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig.1] A sectional view of an electrophoretic display cell when displaying brightly to explain the basic operation of the present invention.

[Fig.2] A sectional view of the electrophoretic display cell when displaying darkly to explain the basic operation of the present invention.

[Fig.3] A sectional view of an electrophoretic display cell when displaying brightly according to one embodiment of the present invention, in

which red electrophoretic particles are combined with a cyan-colored dispersion medium.

[Fig.4] A sectional view of the electrophoretic display cell when displaying darkly according to one embodiment of the present invention, in which red electrophoretic particles are combined with a cyan-colored dispersion medium.

[Fig.5] A sectional view of an electrophoretic display cell according to one embodiment of the present invention, in which green electrophoretic particles are combined with a magenta-colored dispersion medium, when displaying brightly.

[Fig.6] A sectional view of the electrophoretic display cell when displaying darkly according to one embodiment of the present invention, in which green electrophoretic particles are combined with a magenta-colored dispersion medium.

[Fig.7] A sectional view of an electrophoretic display cell when displaying brightly according to one embodiment of the present invention, in which blue electrophoretic particles are combined with a yellow-colored dispersion medium.

[Fig.8] A sectional view of the electrophoretic display cell when displaying darkly according to one embodiment of the present invention, in which blue electrophoretic particles are combined with a yellow-colored dispersion medium.

[Fig.9] A sectional view of an electrophoretic display cell when displaying brightly according to one embodiment of the present invention, in which red electrophoretic particles are combined with a black-colored dispersion medium.

[Fig.10] A sectional view of the electrophoretic display cell when displaying darkly according to one embodiment of the present invention, in

which red electrophoretic particles are combined with a black-colored dispersion medium.

[Fig.11] A sectional view of an electrophoretic display cell when displaying brightly according to one embodiment of the present invention, in which green electrophoretic particles are combined with a black-colored dispersion medium.

[Fig.12] A sectional view of the electrophoretic display cell when displaying darkly according to one embodiment of the present invention, in which green electrophoretic particles are combined with a black-colored dispersion medium.

[Fig.13] A sectional view of an electrophoretic display cell when displaying brightly according to one embodiment of the present invention, in which blue electrophoretic particles are combined with a black-colored dispersion medium.

[Fig.14] A sectional view of the electrophoretic display cell when displaying darkly according to one embodiment of the present invention, in which blue electrophoretic particles are combined with a black-colored dispersion medium.

[Fig.15] A sectional view of an electrophoretic display cell when displaying brightly according to one embodiment of the present invention, in which red electrophoretic particles are combined with a colored dispersion medium made so as to absorb at least a component of red.

[Fig.16] A sectional view of the electrophoretic display cell when displaying darkly according to one embodiment of the present invention, in which red electrophoretic particles are combined with a colored dispersion medium made so as to absorb at least a component of red.

[Fig.17] A sectional view of an electrophoretic display cell when displaying brightly according to one embodiment of the present invention, in

which green electrophoretic particles are combined with a colored dispersion medium made so as to absorb at least a component of green.

[Fig.18] A sectional view of the electrophoretic display cell when displaying darkly according to one embodiment of the present invention, in which green electrophoretic particles are combined with a colored dispersion medium made so as to absorb at least a component of green.

[Fig.19] A sectional view of an electrophoretic display cell when displaying brightly according to one embodiment of the present invention, in which blue electrophoretic particles are combined with a colored dispersion medium made so as to absorb at least a component of blue.

[Fig.20] A sectional view of the electrophoretic display cell when displaying darkly according to one embodiment of the present invention, in which blue electrophoretic particles are combined with a colored dispersion medium made so as to absorb at least a component of blue.

[Fig.21] A sectional view of an electrophoretic display microcapsule when displaying brightly according to one embodiment of the present invention, in which red electrophoretic particles are combined with a black-colored dispersion medium,.

[Fig.22] A sectional view of the electrophoretic display microcapsule when displaying darkly according to one embodiment of the present invention, in which red electrophoretic particles are combined with a black-colored dispersion medium.

[Fig.23] A plan view of a full-color electrophoretic display apparatus in which RGB display cells according to one embodiment of the present invention are juxtaposed.

[Fig.24] A plan view of a full-color electrophoretic display apparatus in which electrophoretic display microcapsules according to one embodiment of the present invention are juxtaposed in RGB display cells.

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[Description of Code]

I. Incidence Light Strength

Irefon. Reflection Brightness for Being Bright

Ireoff. Reflection Brightness for Being Dark

CELL. Electrophoretic Display Cell

S. Dispersion

P. Electrophoretic Particle

L. Dispersion Medium

Sr. Dispersion for Displaying Red

Sg. Dispersion for Displaying Green

Sb. Dispersion for Displaying Blue

Pr. Red Electrophoretic Particle

Pg. Green Electrophoretic Particle

Pb. Blue Electrophoretic Particle

Lc. Cyan Colored Dispersion Medium

Lm. Magenta Colored Dispersion Medium

Ly. Yellow Colored Dispersion Medium

Lk. Black Colored Dispersion Medium

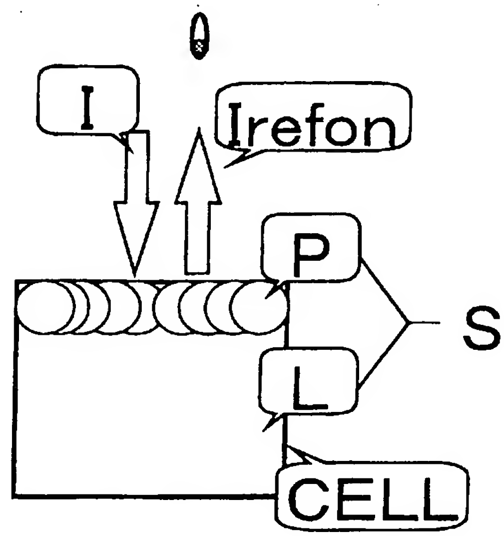
Lkr. Red Color Absorbent Colored Dispersion Medium

Lkg. Green Color Absorbent Colored Dispersion Medium

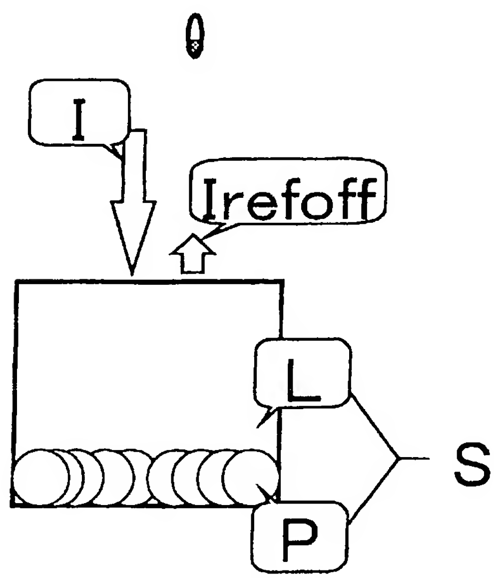
Lkb. Blue Color Absorbent Colored Dispersion Medium

CAPS. Electrophoretic Display Microcapsule

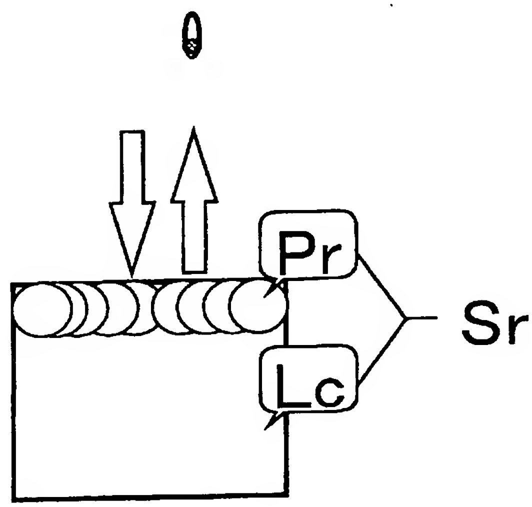
【FIG. 1】



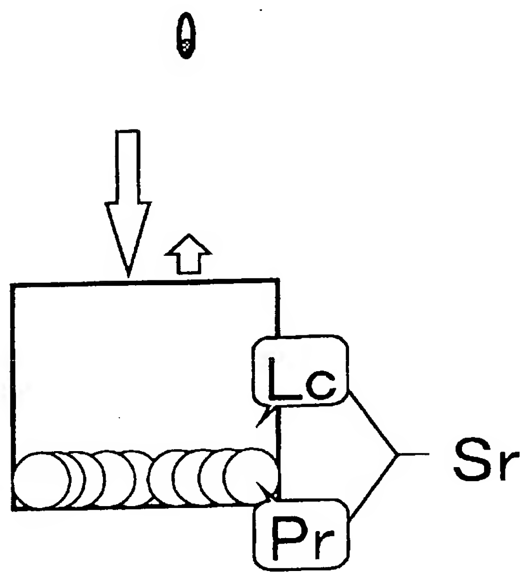
【FIG. 2】



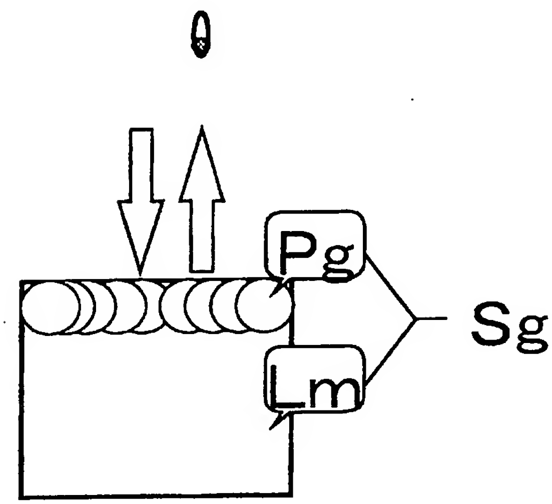
【FIG. 3】



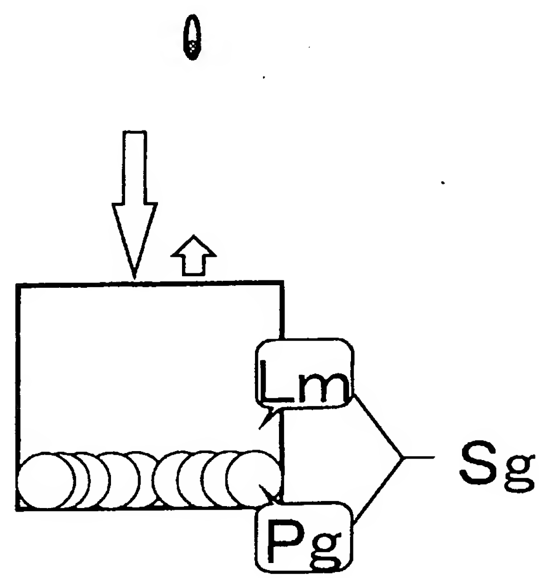
【FIG. 4】



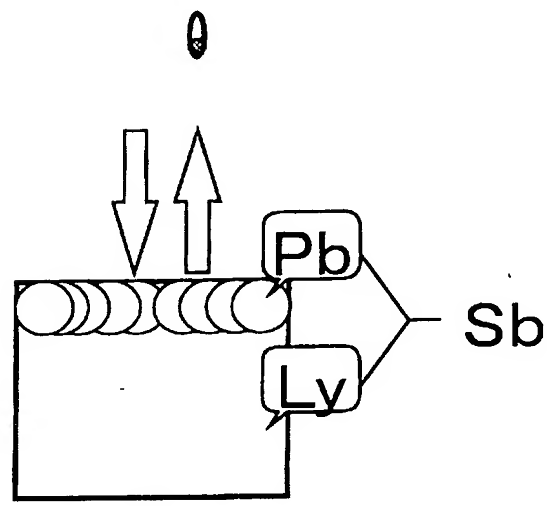
【FIG. 5】



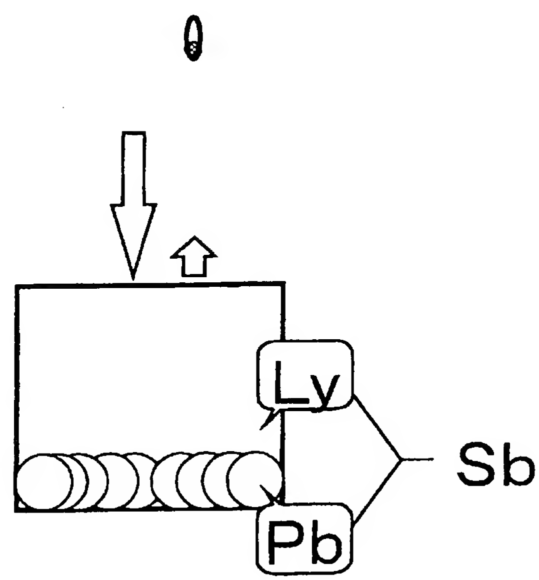
【FIG. 6】



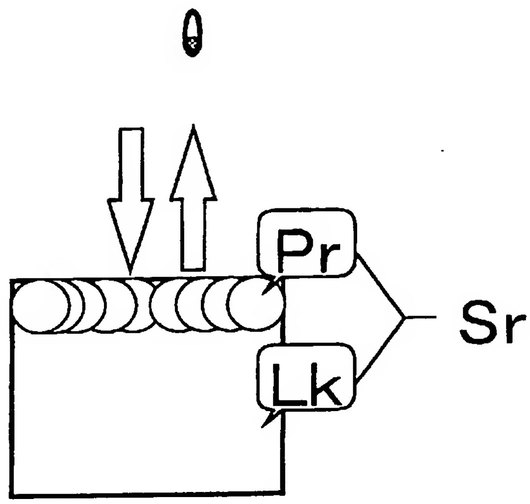
【FIG. 7】



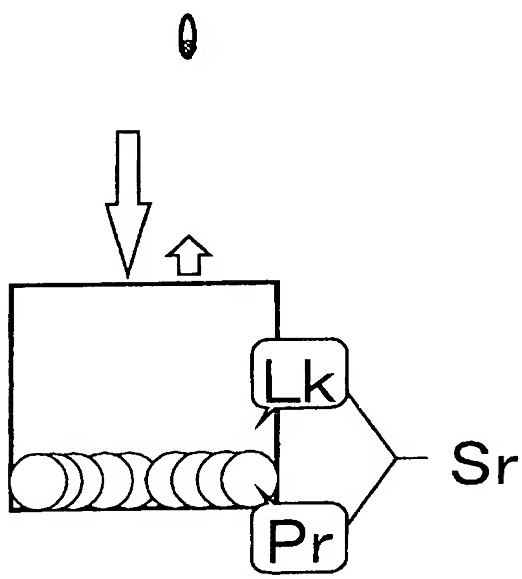
【FIG. 8】



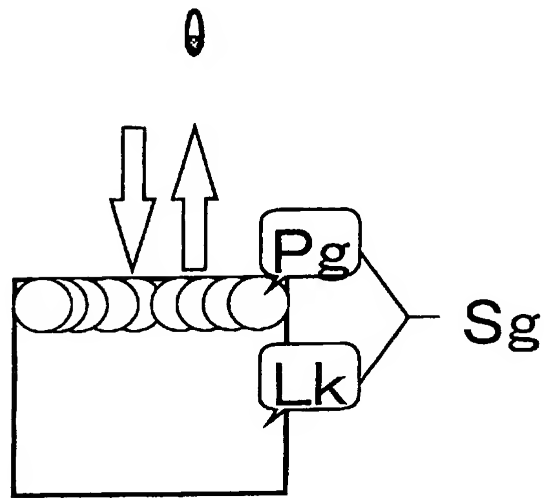
【FIG. 9】



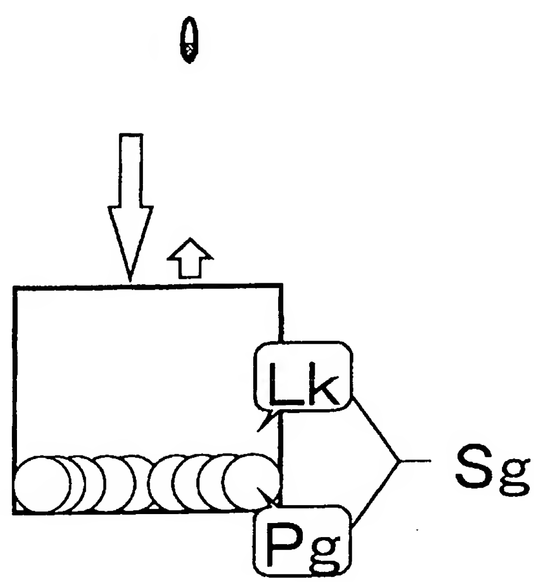
【FIG. 10】



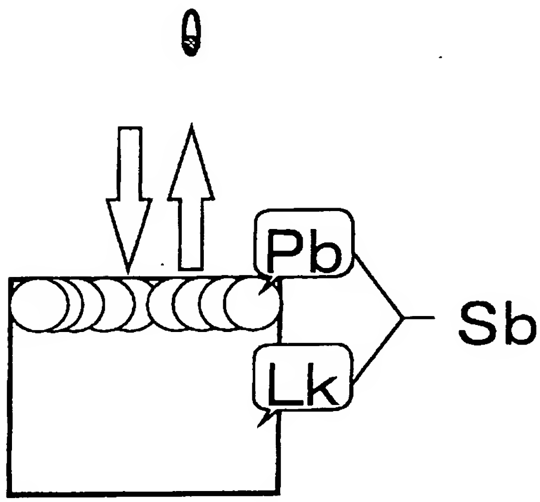
【FIG. 11】



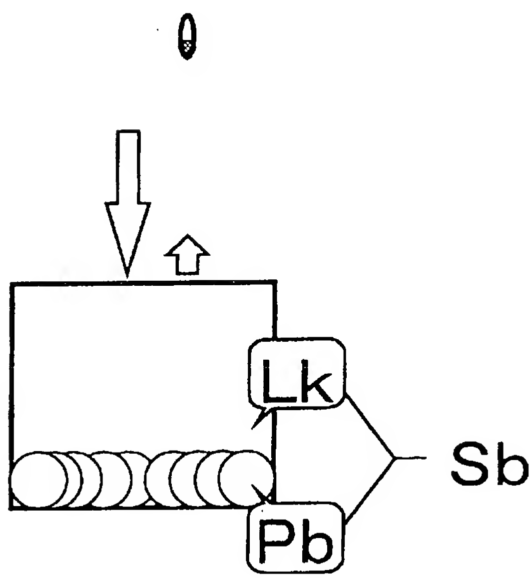
【FIG. 12】



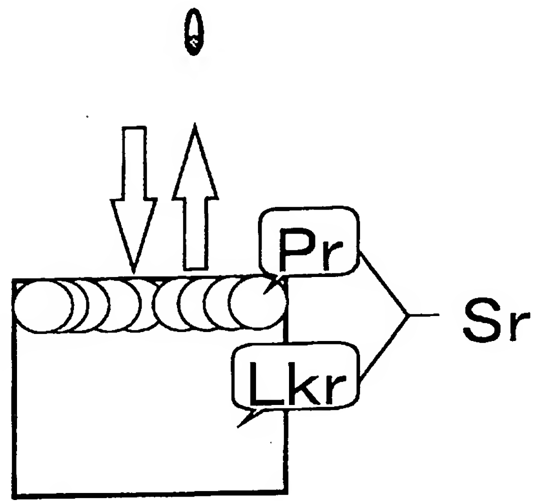
【FIG. 13】



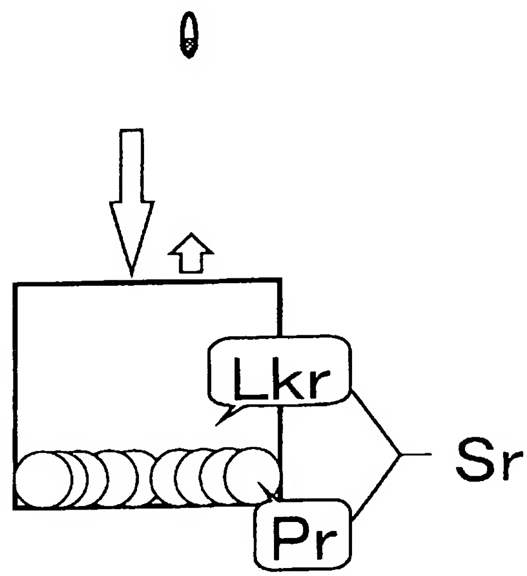
【FIG. 14】



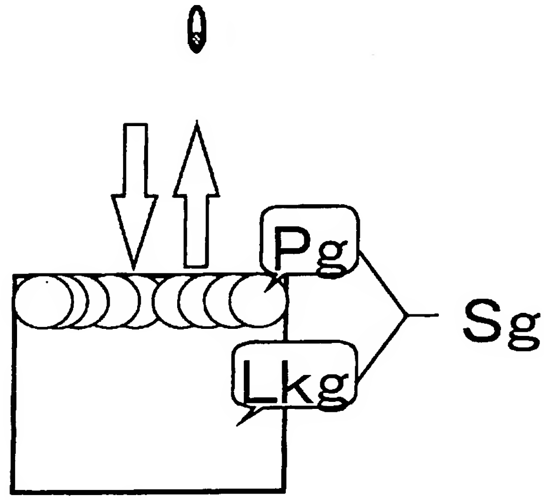
【FIG. 15】



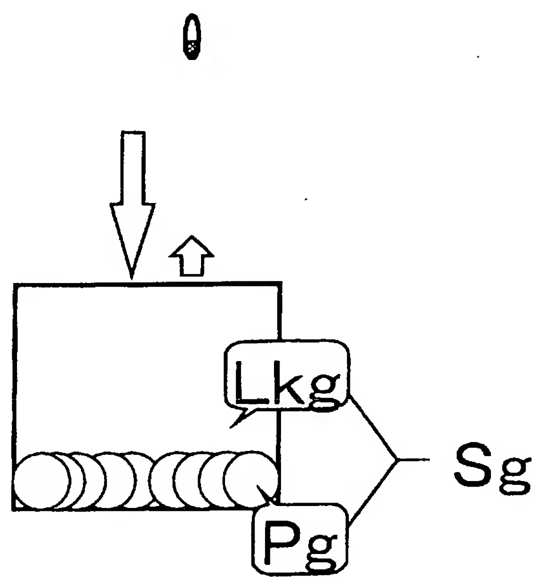
【FIG. 16】



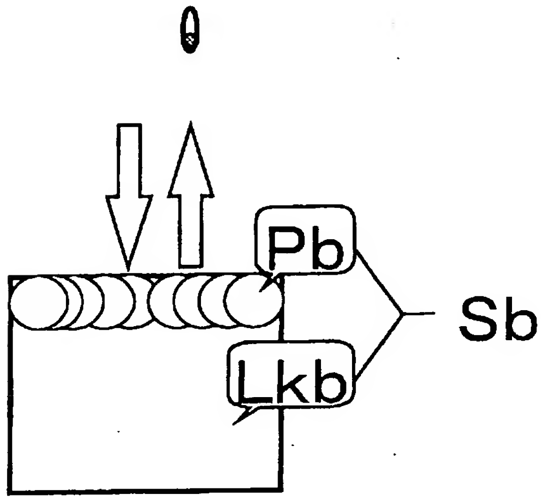
【FIG. 17】



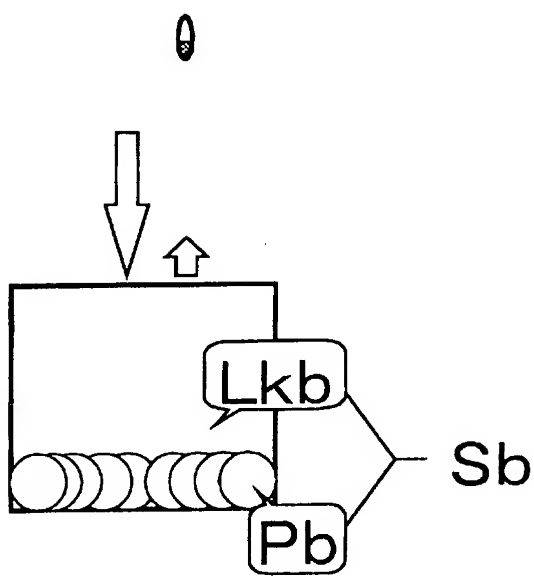
【FIG. 18】



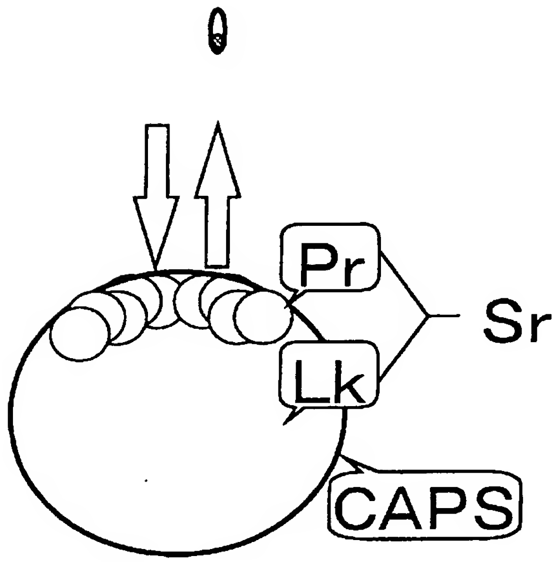
【FIG. 19】



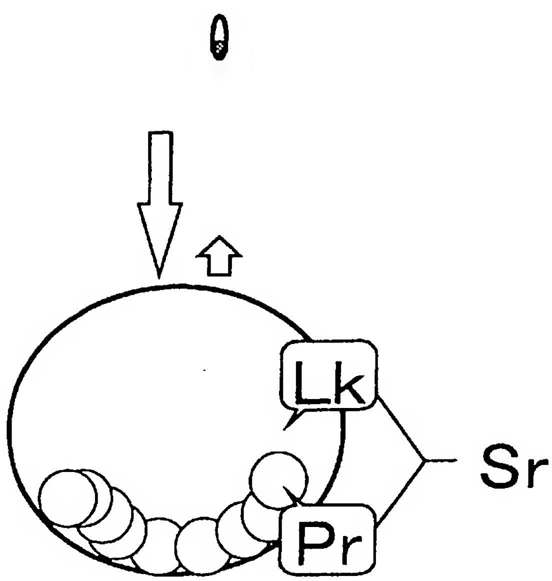
【FIG. 20】



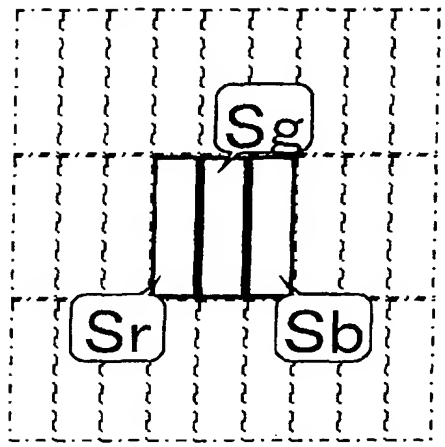
【FIG. 21】



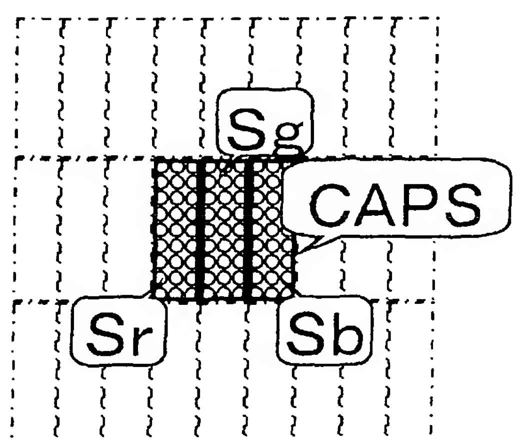
【FIG. 22】



【FIG. 23】



【FIG. 24】



JP2000-104972

[TITLE OF DOCUMENT] ABSTRACT

[ABSTRACT]

[PROBLEM] Achieving color display in an electrooptical device in which electrophoretic particles are dispersed in a dispersion medium.

[MEANS FOR SOLUTION] An electrooptical device comprises an electrooptical layer between electrodes. The above electrooptical layer includes a dispersion medium and particles contained in the dispersion medium. The above particles are colored a first color, while the above dispersion medium is colored a second color. The above first and second colors are related to each other based on a relationship of complementary colors.

[SELECTED FIGURE] Fig.4